United States Patent and Trademark Office

Application No.:	10/613,513
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First Named Inventor:	Brian Y. Lim
Title:	Apparatus and Method for Fabrication of Nanostructures Using Multiple Prongs of Radiating Energy
Examiner:	Maria Alexandra Elve
Art Unit:	1725
Customer No.:	51111
Docket No.:	ATOMP001

Commissioner for Patents
POB 1450
Alexandria, VA 22313-1450

Appellants' Brief in Support of Appeal Under 37 C.F.R. § 1.191

Dear Commissioner:

This is an appeal brief in support of an appeal from the nonfinal office action mailed March 20, 2009. The following items are included in this brief:

Real Party in Interest

The real party in interest is Atomate Corporation, which is the assignee of record.

Related Appeals and Interferences

Appellants are not aware of any related appeals or interferences.

Status of Claims

Claims 1–18 and 29–55 are pending in this application. Claims 19–28 have been canceled.

Claims 1–18 and 29–55 are rejected and the subject of this appeal.

A claims appendix to this appeal brief contains a listing of the pending claims.

Status of Amendments

On March 20, 2009, the examiner has reopened the prosecution (in response to a supplemental brief filed December 8, 2008) and mailed a nonfinal rejection. Appellants have not requested any amendments to the claims after this rejection.

Summary of the Claimed Subject Matter

Claim 1, which is independent, is an apparatus for fabricating nanostructure-based devices on a workpiece (figures 1 and 2; paragraph 16) including: a stage for supporting the workpiece, where the workpiece includes multiple dies, each die having a catalyst on it (paragraphs 18–21); a radiating-energy source, positioned above the stage to locally heat the catalyst on at least one die via simultaneously emitted multiple prongs of radiating energy (figure 1; paragraphs 19, 23, 27); and a feedstock delivery system for delivery of feedstock gas to the catalyst (figure 3; paragraphs 19, 22, and 26).

Claim 11 is where the feedstock delivery system is positionable at least in distance above the die, and in direction of gas flow toward the die (figure 2; paragraph 19).

Claim 16 is where the stage temperature-control unit cools the workpiece to a temperature in a range from an equilibrium room temperature to –250 degrees centigrade (paragraphs 22, 25, and 29).

Claim 29, which is independent, is an apparatus (figures 1 and 2; paragraph 16) including: a stage, for supporting a workpiece having a plurality of work regions, where each

work region will have a catalyst on it (paragraphs 18–21); a temperature control unit, coupled to the stage, to maintain the stage and the workpiece at a first temperature (paragraph 22); a radiating-energy source, above the stage, to locally heat the catalyst of a selected work region to a second temperature, above the first temperature, via multiple prongs of radiating energy (figure 1; paragraphs 19, 23, 27); and a feedstock delivery system for delivery of feedstock gas to the catalyst (figure 3; paragraphs 19, 22, and 26).

Claim 32 is where the temperature control unit cools the stage to the first temperature (paragraphs 22, 25, and 29).

Claim 37 is where an output nozzle of the feedstock delivery system is movable to a position above the stage (figure 3; paragraphs 19 and 24).

Claim 38 is where the feedstock delivery system includes a heating element to heat the feedstock gas to a third temperature before exposing the catalyst to the feedstock gas (figure 2; paragraphs 22 and 29).

Claim 50 is the apparatus including an electric field generator, having an adjustable position relative to the stage, whereby the electric field generated by the generator will influence a direction of nanostructure growth in the selected work region (paragraph 24).

Grounds of Rejection to Be Reviewed on Appeal

I. A first ground of rejection to be reviewed on appeal involves whether claims 8 and 9 are under 35 U.S.C. § 112, second paragraph, unpatentable as being indefinite for failing to particularly point out and distinctly claim the subject matter which appellants regard as the invention.

II. A second ground of rejection to be reviewed on appeal involves whether claims 1-18 and 29–55 are under 35 U.S.C. § 101 provisionally unpatentable as claiming the same invention as that of claims 1–36 of application 10/613,217.

III. A third ground of rejection to be reviewed on appeal involves whether claims 1-3, 6-7, 9, 11-14, and 18 are under 35 U.S.C. § 103(a) unpatentable over U.S. patent 6,756,026 (Colbert) in view of PCT application publication WO02/081366 (Dai).

IV. A fourth ground of rejection to be reviewed on appeal involves whether claims 4-5 and 10 are under 35 U.S.C. § 103(a) unpatentable over U.S. patent 6,756,026 (Colbert) in view

of PCT application publication WO02/081366 (Dai), and further in view of U.S. patent 6,801,350 (Glasner-Inbari).

V. A fifth ground of rejection to be reviewed on appeal involves whether claims 15-17 and 29-46 are under 35 U.S.C. § 103(a) unpatentable over U.S. patent 6,756,026 (Colbert) in view of PCT application publication WO02/081366 (Dai), and further in view of U.S. patent application publication 2002/0127170 (Hong).

VI. A sixth ground of rejection to be reviewed on appeal involves whether claims 47-49 and 52-55 are under 35 U.S.C. § 103(a) unpatentable over U.S. patent 6,756,026 (Colbert), PCT application publication WO02/081366 (Dai), and U.S. patent application publication 2002/027170 (Hong) in view U.S. patent 6,801,350 (Glasner-Inbari).

VII. A seventh ground of rejection to be viewed on appeal involves whether claims 50 and 51 are under 35 U.S.C. § 103(a) unpatentable over U.S. patent 6,756,026 (Colbert), PCT application publication WO02/081366 (Dai), and U.S. patent application publication 2002/0127170 (Hong) in view U.S. patent 6,683,783 (Smalley).

Argument

I. Argument Against First Ground of Rejection

Claims 8 and 9 were rejected under section 112, second paragraph, for failing to particularly point out and distinctly claim the subject matter which appellants regard as the invention. Appellants believe this rejection is improper for the reasons discussed below.

Regarding claim 8, the examiner states in her March 20, 2009 office action, "it is not clear how a set of islands of catalyst can be associated with one die. Is the die very large, are the catalyst areas scattered about?" Regarding claim 9, the examiner states, "Is the catalyst on, in or near the die(s)?"

However, one of skill in the semiconductor processing arts would understand that semiconductor fabrication involves patterning regions (e.g., islands). An entire die, or multiple dies, of a wafer can be patterned, if so desired; or, within a single die, multiple regions can be patterned, if so desired. Patterned regions within a die (or in multiple dies) can contain a catalyst to cause nanotubes to grow in these regions. Appellants believe the claims are sufficiently definite to one of skill in the art. The rejection should be withdrawn.

II. Argument Against Second Ground of Rejection

Claims 1–18 and 29–55 were provisionally rejected under 35 U.S.C. § 101 as claiming the same invention as that of claims 1–36 of application 10/613,217. However, U.S. patent application 10/613,217 is not pending, and therefore this provisional rejection is not proper. The provisional rejection should be withdrawn.

III. Argument Against Third Ground of Rejection

Claims 1-3, 6-7, 9, 11-14, and 18 were rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. patent 6,756,026 (Colbert) in view of PCT application publication WO02/081366 (Dai). Appellants believe this rejection is improper for the reasons discussed below.

For this argument, the claims are grouped as follows:

Group III.1: Claims 1–3, 6-7, 9, 13-14, and 18 stand or fall together.

Group III.2: Claims 11–12 stand or fall together.

Principles of Law Relating to Obviousness

"Section 103 forbids issuance of a patent when 'the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains.'" *KSR Int'l Co. v. Teleflex Inc.*, 127 S.Ct. 1727, 1734, 82 U.S.P.Q.2d 1385, 1391 (2007). The question of obviousness is resolved on the basis of underlying factual determinations including (1) the scope and content of the prior art, (2) any differences between the claimed subject matter and the prior art, (3) the level of skill in the art, and (4) where in evidence, so-called secondary considerations. *Graham v. John Deere Co.*, 383 U.S. 1, 17–18, 148 U.S.P.Q. 459, 467 (1966). Secondary considerations such as commercial success, long felt but unsolved needs, failure of others, and so forth, "might be utilized to give light to the circumstances surrounding the origin of the subject matter sought to be patented." 383 U.S. at 18, 148 U.S.P.Q. at 467. See also *KSR*, 127 S.Ct. at 1734, 82 U.S.P.Q.2d at 1391 ("While the sequence of these questions might be reordered in any particular case, the [*Graham*] factors continue to define the inquiry that controls.").

Group III.1: Claims 1–3, 6-7, 9, 13-14, and 18

Claim 1 recites "a radiating-energy source, positioned above the stage *to locally heat the catalyst on at least one die via simultaneously emitted multiple prongs of radiating energy*."

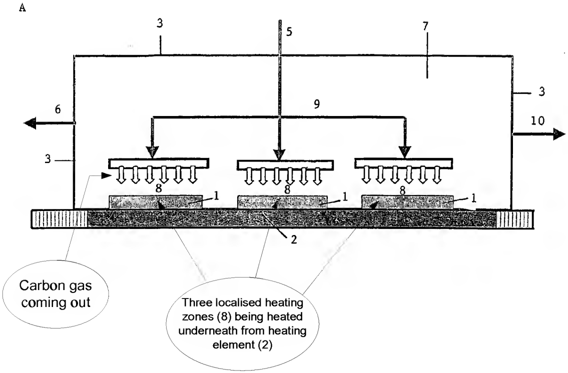
Claims 2-3, 6-7, 9, 13-14, and 18, directly or indirectly, depend upon claim 1.

The Prior Art References Do Not Teach or Suggest Essential Claim Elements

Claim 1 recites, *inter alia*, that "multiple prongs of radiating energy" are used to locally heat the catalyst on at least one die, where a radiating-energy source is positioned above the stage. While the examiner admits that Colbert does not teach this element, the examiner copies and refers to figure 1B of Dai in the office action and states that Dai describes "localized heating zones (8) [that] have multiple heating prongs or laser beam prongs." See page 4 of the office action.

Appellants respectfully disagree. The examiner's reliance of Dai's figure 1B for teaching of multiple prongs of radiating energy is misplaced. Figure 1B of Dai is shown below (with comments in bubbles added by appellants).

Figure 1B .



The multiple prongs (*i.e.*, three sets of six arrows pointing downward) shown in figure 1B of Dai have nothing to do with radiating energy. Rather, the three sets of multiple arrows pointing downward indicate the direction of carbon containing gas distribution. At page 13, lines 25-27, Dai states that "[t]he gas inlet (5) is connected to a gas distributor (9) that allows the carbon-containing material to be simultaneously introduced into multiple localized heating zones (8)." Localized heating zones (8) in Dai refer to three blocks of substrates (1) which are sitting on top of and being heated by a heating element (2). Thus, contrary to the examiner's statement, Dai does not teach or suggest the use of multiple of prongs of radiating energy, as recited claim1.

Since neither Colbert nor Dai teach or suggest the essential element "multiple prongs of radiating energy" as recited in claim 1, the rejections are improper and should be withdrawn at least for this reason.

The Prior Art References Teach Away from Each Other

Colbert and Dai teach away from each other, and one of ordinary skill in the art would not have modified Colbert in view of Dai. Colbert discusses a method of growing carbon fiber from single carbon nanotube molecular arrays. "The catalyst is formed, in situ, on the open tube ends of the molecular array" to further grow the carbon fiber. See column 25, lines 1-2. Colbert further states that "***the only*** heat supplied for the growth reaction should be focused at the growing tip of the fiber 1004. The rest of the fiber and the reaction apparatus can be kept at room temperature… [A] laser 1006 focused at the growing end is preferred." See column 26, lines 35-42.

The examiner alleges that it would have been obvious to modify Colbert's heating method in order "to use multiple prongs for heating as taught by Dai" See page 4 of the office action. As noted above, contrary to the examiner's allegation, Dai does not teach multiple prongs of radiating energy. *Assuming arguendo* Dai describes multiple prongs or radiating energy, one of ordinary skill in the art would not have applied multiple prongs of radiating energy to Colbert's heating method because it would be against Colbert's desire that "***the only*** heat supplied for the growth reaction should be focused growing tip of the fiber." If multiple prongs of radiating energy were to be applied to Colbert, the radiating energy may no longer be focused at the growing fiber tip and may be diffused to other parts of the fiber. Thus, one of ordinary skill in the art would not have modified Colbert's heating method in view of Dai.

Furthermore, Dai is concerned with providing homogenous heating of the substrate (see, e.g., page 12, line 28) so that it is possible to prepare multilayer carbon nanotubes and hetero-structured multilayer carbon nanotube films. "In a preferred embodiment, the heating element also acts as the support means for the substrate… Preferably, the heating element allows the substrate to be heated homogenously." See page 5, lines 5-11. The Colbert's approach of heating just a fiber tip is completely the opposite of Dai's approach of heating the entire substrate homogenously. One viewing Dai's heating method would not have modified the heating approach taught by Colbert as it would go against Colbert's desire to apply the heat only to the growing tip of the fiber.

In summary, Colbert and Dai teach away from each other, and one of ordinary skill in the art would not have modified the heating method of Colbert in view of Dai. The examiner has not made a showing of obviousness. For at least this reason, claim 1 and the other claims in this group should be allowable.

Combination Falls Short

Even if Colbert were combined with Dai, and there is no basis for doing this for the reason stated above, the combination will still fall short of invention as recited in the claim.

Claim 1 also recites, *inter alia*, that a radiating-energy source is "to locally heat the catalyst on at least one die," where the workpiece (e.g., substrate) includes multiple dies. In other words, the claim requires that the radiating-energy source has the ability to locally heat catalyst on at least one die, without directly heating catalyst at one or more other dies of the workpiece. As described at page 7, paragraph 20 of the specification, "one work region can be individually processed, followed by a next work region, and so forth. Uniformity, reproducibility, and reliability of the integrated nanostructures is enhanced by working on only one work region at a time."

Neither Colbert nor Dai describes selectively heating one die or work region among many dies in the workpiece. As described above, Colbert is concerned with applying heat to the fiber tip to make a carbon fiber grow. On the other hand, Dai discusses heating the entire substrate homogenously. Colbert or Dai, alone or in combination, do not teach or suggest locally heating catalyst on at least one die among many dies in a workpiece. Accordingly, even if

Colbert nor Dai were combined, the combination still falls short of arriving at the claimed invention.

For at least this additional reason, claim 1 and the other claims in this group should be allowable.

Group III.2: Claims 11–12

Claim 11 recites "wherein the feedstock delivery system is positionable at least in distance above the die, and in direction of gas flow toward the die."

Claim 12 recites "wherein the feedstock delivery system is positionable in X, Y, and Z directions."

Nowhere does Colbert or Dai show or suggest this feature of the invention. The cited prior art references do not show or suggest a positionable feedstock delivery system.

The invention permits positioning, relative to the stage, of delivery of the feedstock gas to the catalyst. Being able to position the stage is different from being able to position the feedstock gas. When moving the stage, the stage moves relative to the radiating-energy source. In contrast, the invention as claimed allows the feedstock delivery system to be positioned independently of a position of the stage. Thus, the stage can maintain its relative position to the radiating-energy source even when the feedstock delivery system changes position.

For at least this reason, the claims in this group should be allowable.

Further, the claims in this group include limitations discussed in other groups (e.g., group III.1 above). These claims should be allowable for at least the reasons discussed in this group and for the additional reasons discussed in the other groups.

IV. Argument Against Fourth Ground of Rejection

Claims 4-5 and 10 were rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. patent 6,756,026 (Colbert) in view of PCT application publication WO02/081366 (Dai), and further in view of U.S. patent 6,801,350 (Glasner-Inbari). Appellants believe this rejection is improper for the reasons discussed below.

Claim 4 recites that "the multiple laser beams originate from a single laser split by at least one beam splitter."

Claim 5 recites that "the multiple laser beams comprise at least ten laser beams."

Claim 10 recites that "the radiating-energy source includes a beam splitter, wherein a plurality of the multiple prongs are produced by the beam splitter from beams that number fewer than the plurality."

On page 4 of the office action, the examiner alleges that "[a]lthough multiple prongs, i.e., multiple laser beams are taught, an actual beam splitter is not taught." Then, the examiner relies on Glasner-Inbari for disclosure of a beam splitter and concludes that it would have been obvious to modify Colbert and Dai "to use a beam splitter to form multiple beams because this is a common device used in laser systems for [forming] multiple beams." See page 5 of the office action.

Obviousness has not been established, because there is no articulated reasoning with some rational underpinning to support the conclusion of obviousness. As explained in the PTO's own guidelines on *KSR International Co. v. Teleflex Inc.*: 82 USPQ2d 1385 (2007):

> *The key to supporting any rejection under 35 U.S.C. 103 is the clear articulation of the reason(s) why the claimed invention would have been obvious.* The Supreme Court in KSR noted that the analysis supporting a rejection under 35 U.S.C. 103 should be made explicit. The Court quoting In re Kahn[41] stated that '''[R]ejections on obviousness cannot be sustained by mere conclusory statements; instead, *there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness.*'''

Here, the examiner alleges that it would have been obvious to modify Colbert and Dai to include a beam splitter to form multiple beams because this is "a common device" used in laser systems. An allegation that a beam splitter is "a common device" is not a reason why one of ordinary skill in the art would have modified Colbert or Dai to include a beam splitter of Glasner-Inbari. The fact that a beam splitter is a known device does not necessarily lead one of ordinary skill in the art to include it in all laser systems. In fact, as described above (e.g., in group III.1), Colbert and Dai teach away from using multiple prongs of radiating energy, and one of ordinary skill in the art would not have included a beam splitter of Glasner-Inbari to produce multiple prongs of radiating energy. As the examiner has not provided any articulated reasoning with some rational underpinning why one of skill in the art would have included a beam splitter of Glasner-Inbari in Colbert and Dai, obviousness has not been established.

Furthermore, while Glasner-Inbari discusses the use of a beam splitter, it is used in the art of optical disk drives and optical scanning. Glasner-Inbari states that "[t]o be able to read data, an optical disk drive needs to focus laser light to a spot about 1 μm or less in diameter on a recording surface area of the disk, then collect the light reflected from that spot." See column 1, lines 12-15. The beam splitter is used by Glasner-Inbari so that the data transfer rate can be multiplied by the number of beams/detectors. See column 17, lines 28-31. The function of the laser beam in Glasner-Inbari is to read optical data, whereas the function of a laser in Colbert and Dai is to heat a catalyst to make carbon nanotubes. Clearly, the power output and other requirements for the Glasner-Inbari's laser system and the requirements for the Colbert's and Dai's laser system would be very dissimilar. Even if a beam splitter were "a common device" used in optical disk drives and optical scanning, as alleged by the examiner, this would not have lead one of ordinary skill in the art to apply a beam splitter of Glasner-Inbari to Colbert and Dai's heating methods as the functions of the laser and beam splitter are completely different in these references.

In summary, the examiner has not met her burden of showing obviousness, and the rejection is improper. These claims should be allowable for at least the reasons discussed in this group and for the additional reasons discussed in group III above.

V. Argument Against Fifth Ground of Rejection

Claims 15-17 and 29-46 were rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. patent 6,756,026 (Colbert) in view of PCT application publication WO02/081366 (Dai), and further in view of U.S. patent application publication 2002/0127170 (Hong). Appellants believe this rejection is improper for the reasons discussed below.

For this argument, the claims are grouped as follows:

Group V.1: Claims 15, 17, 29-36, and 39-46 stand or fall together.

Group V.2: Claim 16 stands or falls by itself.

Group V.3: Claim 37 stands or falls by itself.

Group V.4: Claim 38 stands or falls by itself.

Group V.1: Claims 15, 17, 29-36, and 39-46

Claim 15 recites that "the stage includes a stage temperature-control unit for helping to control a temperature of a workpiece."

Claim 17 depends upon claim 15.

Claim 29 is another independent claim which recites limitations that are substantially similar to those recited in claim 1. Thus, the arguments presented above for claim 1 are also applicable to claim 29 and its dependent claims. In addition, claim 29 recites "a temperature control unit, coupled to the stage, to maintain the stage and the workpiece at a first temperature."

Claims 30-36 and 39-46, directly or indirectly, depend upon claim 29.

The examiner states that "[a]lthough the system is used for carbon nanotube fabrication and temperature is disclosed, temperature control is not specifically taught." See page 5 of the office action. Then the examiner relies on Hong and concludes that "[i]t would have been obvious to one skilled in the art to use feedstock gas delivery line temperature controller 500 of Hong because this temperature level is critical to the reaction and hence it is required that i[t] be controlled." See page 6 of the office action.

The rejection is improper, because Hong does not teach or suggest temperature-control unit limitation as recited in claims 15 and 29. Claims 15 and 29 recite that ***the stage*** which supports the workpiece includes a stage temperature-control unit for helping to control a temperature of a workpiece. By contrast, Hong's temperature controller 500 is provided to maintain the catalyst in a gas phase, which is acknowledged by the examiner. Hong's temperature controller has nothing to do with controlling the temperature of the stage supporting the workpiece or the workpiece itself. In fact, Hong's support 130 onto which catalyst 135 is loaded is the powder type, which is later introduced into a reactor in a boat. See paragraphs [32], [39], and [40] of Hong. Hong does not even utilize a stage to place a support (i.e., substrate), let alone teach or suggest using a stage temperature-control unit.

The examiner has failed to establish obviousness for reasons described above. Accordingly, the rejection is improper, and these claims should be allowable for at least the reasons discussed in this group and for the additional reasons discussed above in other group.

Group V.2: Claim 16

Claim 16 recites "the stage temperature-control unit *cools the workpiece to a temperature in a range from an equilibrium room temperature to –250 degrees centigrade*." Nowhere do the prior art references show or suggest this feature of the invention. While Dai discusses moving a substrate from a localized heating zone to a cooling zone in figure 1CB, the heating zone and the cooling zone are within a single reactor and the cooling zone is used to allow the substrate to cool before being removing it from the reactor. There is no teaching or suggestion that the cooling zone in Dai can be used to cool the workpiece to a temperature in a range from an equilibrium room temperature *to -250 degrees centigrade*.

More specifically, while simply removing the substrate from a heating zone might cool the wafer, this would not cool any workpiece *down to a temperature of -250 degrees centigrade* without *violating the laws of thermodynamics* (i.e., the first law of thermodynamics says that in any process in an isolated system, the total energy remains the same). Dai does not describe anything that would make it technically feasible so the cooling zone might cool the workpiece down *to -250 degrees centigrade*. Therefore, the combination of references the examiner suggests appears to violate fundamental principles, and so obviousness has not been established by the cited references.

For at least this reason, claim 16 should be allowable.

Further, the claim in this group includes limitations discussed in other groups (e.g., group III and group V.1 above). This claim should be allowable for at least the reasons discussed in this group and for the additional reasons discussed in the other groups.

Group V.3: Claim 37

Claim 37 recites "wherein an *output nozzle of the feedstock delivery system is movable to position above the stage*." The combination of Colbert, Dai, and Hong do not show or suggest an output nozzle of the feedstock delivery system that is movable. See argument in group III.2 above. For at least this reason, claim 37 should be allowable.

Further, the claim in this group includes limitations discussed in other groups (e.g., group V.1 above). These claims should be allowable for at least the reasons discussed in this group and for the additional reasons discussed in the other groups.

Group V.4: Claim 38

Claim 38 recites "wherein the feedstock delivery system comprises *a heating element to heat the feedstock gas to a third temperature* before exposing the catalyst to the feedstock gas."

The combination of Colbert, Dai, and Hong do not show or suggest a heating element to heat the feedstock gas to a third temperature. Nowhere do the cited references show or suggest, first, second, and third temperatures.

For at least this reason, claim 38 should be allowable.

Further, the claim in this group includes limitations discussed in other groups (e.g., group V.1 above). This claim should be allowable for at least the reasons discussed in this group and for the additional reasons discussed in the other groups.

VI. Argument Against Sixth Ground of Rejection

Claims 47-49 and 52-55 were rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. patent 6,756,026 (Colbert), PCT application publication WO02/081366 (Dai), and U.S. patent application publication 2002/027170 (Hong) in view U.S. patent 6,801,350 (Glasner-Inbari).

The examiner states that "[a]lthough multiple prongs, i.e., multiple laser beams are taught, an actual beam splitter is not taught." See page 6 of the office action. Then examiner relies on Glasner-Inbari and concludes that it would have been obvious to one of ordinary skill in the art to modify Colbert, Dai, and Hong "to use a beam splitter to form multiple beams because this is a common device used in laser systems for [forming] multiple beams." See pages 6-7 of the office action.

This rejection is essentially identical to the fourth ground of rejection. Appellants believe that this rejection is improper for the reasons set forth in group IV above. This group of claims should be allowable for at least the reasons discussed above in group IV and for the additional reasons discussed in the other groups.

VII. Argument Against Seventh Ground of Rejection

Claims 50 and 51 were rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. patent 6,756,026 (Colbert), PCT application publication WO02/081366 (Dai), and U.S. patent application publication 2002/0127170 (Hong), and further in view U.S. patent 6,683,783 (Smalley).

Claim 50 recites that the apparatus further includes "an electric field generator, having an adjustable position relative to the stage, whereby the electric field generated by the generator will influence a direction of nanostructure growth in the selected work region."

Claim 51 recites that the apparatus further includes "a magnetic field generator, having an adjustable position relative to the stage, whereby the magnetic field generated by the generator will influence a direction of nanostructure growth in the selected work region."

The examiner states that while the application of an electric/magnetic field is not taught [by Colbert, Dai, or Hong], Smalley discloses carbon fiber formation (nanotubes) in which an electromagnetic field is applied to orient the nanotube during growth. Then the examiner concludes that it would have been obvious for one of ordinary skill in the art "to use an electromagnetic field as taught by Smalley in the Colbert system because this orients the nanotubes, forming arrays." See page 7 of the office action.

Appellants respectfully requests the examiner to specifically point to a passage in Smalley where it states that "an electromagnetic field is applied to orient the nanotubes during growth," as alleged in the office action. While Smalley describes that an electromagnetic field in the vicinity of modified nanotube assemblies can induce electrical currents in the assemblies (see column 35, lines 7-12), there is no teach or suggestion for using an electric field generator or magnetic generator to influence a direction of nanostructure growth in the selected region. Further, there is no teaching or suggestion for placing an electric field generator or a magnetic field generator having an adjustable position relative to the stage.

Since the essential claim elements are not taught by suggested by the cited references, the rejection is improper. Accordingly, the rejection should be withdrawn and the claims should be allowable.

Conclusion

For the above reasons, appellants submit that the examiner's rejections of the claims should be withdrawn, and reversal of the examiner's decision is respectfully requested.

Respectfully submitted,

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/Melvin D. Chan/

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Attachments: Claims Appendix
Evidence Appendix
Related Proceedings Appendix

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Claims Appendix

1. An apparatus for fabricating nanostructure-based devices on a workpiece comprising:

a stage for supporting the workpiece, wherein the workpiece includes multiple dies, each die having a catalyst on it;

a radiating-energy source, positioned above the stage to locally heat the catalyst on at least one die via simultaneously emitted multiple prongs of radiating energy; and

a feedstock delivery system for delivery of feedstock gas to the catalyst.

2. The apparatus of claim 1 wherein the radiating-energy source is a laser source, and the multiple prongs are multiple laser beams.

3. The apparatus of claim 2 wherein the multiple laser beams comprise a type selected from the set consisting of YAG, excimer, CO_2, argon, helium-neon, ruby, neodymium glass, semiconductor, and free electron.

4. The apparatus of claim 2 wherein the multiple laser beams originate from a single laser split by at least one beam splitter.

5. The apparatus of claim 2 wherein the multiple laser beams comprise at least ten laser beams.

6. The apparatus of claim 1 wherein the radiating-energy source includes at least one of a focused acoustic, focused radio frequency (RF), focused infrared (IR), or focused microwave source.

7. The apparatus of claim 1 wherein the apparatus is configured to permit the multiple prongs to be positioned and aligned so that all catalyst throughout the die that are desired for seeding growth are irradiated.

8. The apparatus of claim 1 wherein the apparatus is configured to permit the multiple prongs to be positioned and aligned so that all catalyst throughout die that are desired for seeding growth are irradiated in multiple irradiating periods, in which a set of islands of catalyst irradiated in a first irradiating period is not identical to a set of islands of catalyst irradiated in a second irradiating period.

9. The apparatus of claim 1 wherein the apparatus is configured to permit the multiple prongs to be positioned and aligned so that all catalyst throughout die that are desired for seeding growth are irradiated in multiple irradiating periods, in which each period of said multiple periods uses a different set of fabrication parameters.

10. The apparatus of claim 1 wherein the radiating-energy source includes a beam splitter, wherein a plurality of the multiple prongs are produced by the beam splitter from beams that number fewer than the plurality.

11. The apparatus of claim 1 wherein the feedstock delivery system is positionable at least in distance above the die, and in direction of gas flow toward the die.

12. The apparatus of claim 1 wherein the feedstock delivery system is positionable in X, Y, and Z directions.

13. The apparatus of claim 1 wherein the stage can be is configured to be capable of being translated or rotated relative to the radiating-energy source, whereby any die of the workpiece is capable of being positioned for exposure to said radiating-energy source.

14. The apparatus of claim 1 wherein the apparatus is configured to permit at least a portion of said radiating-energy source to be translated or rotated relative to the stage, whereby the multiple prongs are capable of being selectively positioned for radiating energy onto any given die of the workpiece.

15. The apparatus of claim 1 wherein the stage includes a stage temperature-control unit for helping to control a temperature of the workpiece.

16. The apparatus of claim 15 wherein the stage temperature-control unit cools the workpiece to a temperature in a range from an equilibrium room temperature to –250 degrees centigrade.

17. The apparatus of claim 15 wherein the stage temperature-control unit heats the workpiece to a temperature in a range from an equilibrium room temperature to 1200 degrees centigrade.

18. The apparatus of claim 1 wherein the apparatus is for fabricating carbon nanostructure-based devices.

29. An apparatus comprising:

a stage, for supporting a workpiece having a plurality of work regions, wherein each work region will have a catalyst on it;

a temperature control unit, coupled to the stage, to maintain the stage and the workpiece at a first temperature;

a radiating energy source, above the stage, to locally heat the catalyst of a selected work region to a second temperature, above the first temperature, via multiple prongs of radiating energy; and

a feedstock delivery system for delivery of feedstock gas to the catalyst.

30. The apparatus of claim 29 wherein the multiple prongs of radiating energy are simultaneously emitted by the radiating energy source.

31. The apparatus of claim 29 wherein the temperature control unit heats the stage to the first temperature.

32. The apparatus of claim 29 wherein the temperature control unit cools the stage to the first temperature.

33. The apparatus of claim 29 wherein the selected work region will comprise a plurality of nanostructure devices.

34. The apparatus of claim 29 wherein the radiating energy source comprises focused infrared radiation.

35. The apparatus of claim 29 wherein the radiating energy source comprises a laser.

36. The apparatus of claim 29 further comprising:

a temperature sensor, coupled to the stage, to monitor a temperature of the workpiece.

37. The apparatus of claim 29 wherein an output nozzle of the feedstock delivery system is movable to position above the stage.

38. The apparatus of claim 29 wherein the feedstock delivery system comprises a heating element to heat the feedstock gas to a third temperature before exposing the catalyst to the feedstock gas.

39. The apparatus of claim 29 wherein work regions other than the selected work region are at the first temperature.

40. The apparatus of claim 29 wherein in the selected work region, a plurality of nanotube structures will be formed.

41. The apparatus of claim 40 wherein in work regions other than the selected work region, nanotube structures are not formed.

42. The apparatus of claim 29 wherein in the selected work region, a plurality of nanowire structures will be formed.

43. The apparatus of claim 42 wherein in work regions other than the selected work region, nanowire structures are not formed.

44. The apparatus of claim 29 wherein the first and second temperatures are set independently of each other.

45. The apparatus of claim 38 wherein the third temperature is different from the first and second temperatures.

46. The apparatus of claim 38 wherein the first, second, and third temperatures are set independently of each other.

47. The apparatus of claim 29 wherein there are more than ten prongs of radiating energy.

48. The apparatus of claim 29 wherein there are more than fifty prongs of radiating energy.

49. The apparatus of claim 29 wherein there are more than one hundred prongs of radiating energy.

50. The apparatus of claim 29 further comprising:

an electric field generator, having an adjustable position relative to the stage, whereby the electric field generated by the generator will influence a direction of nanostructure growth in the selected work region.

51. The apparatus of claim 29 further comprising:

a magnetic field generator, having an adjustable position relative to the stage, whereby the magnetic field generated by the generator will influence a direction of nanostructure growth in the selected work region.

52. The apparatus of claim 29 wherein the multiple prongs of radiating energy are parallel to each other.

53. The apparatus of claim 29 wherein the multiple prongs of radiating energy are not parallel to each other.

54. The apparatus of claim 52 wherein the multiple prongs of radiating energy are perpendicular to a surface of the selected work region.

55. The apparatus of claim 52 wherein the multiple prongs of radiating energy are at an angle other than perpendicular to a surface of the selected work region.

Evidence Appendix

None

Related Proceedings Appendix

None